Radiative-transfer modeling of spectra of planetary regoliths using cluster-based dense packing modifications

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Over the last several decades, a wealth of remote sensing data has been collected for various solar system objects. However, the development of analysis techniques that lead to quantitative interpretations of such datasets has been comparably deficient, especially for regoliths with particle sizes on the order of or smaller than wavelength of light utilized for remote sensing. Radiative transfer theory has often been applied to the study of densely packed particulate media like planetary regoliths, but with difficulty, and here we continue to investigate radiative transfer modeling of spectra of densely packed particulate media. We use the superposition T-matrix method to compute scattering properties of clusters of particles and capture the near-field effects important for dense packing. Then, these scattering parameters are modified with the static structure factor correction, accounting for the dense packing of the clusters themselves. Using the corrected scattering parameters, reflectance (or emissivity via Kirchhoff's Law) is computed via the invariant imbedding solution to the scalar radiative transfer equation. We modeled the emissivity spectrum of the 3.3 μm particle size fraction of enstatite, representing a common regolith component, in the mid-infrared (~5–50 μm). The use of the static structure factor correction coupled with the superposition T-matrix method produced better agreement with the corresponding laboratory spectrum than the sole use of the T-matrix method. This work demonstrates the importance of proper treatment of the packing effects of the clusters themselves when modeling semi-infinite densely packed particulate media using finite, cluster-based light scattering models.

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